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Cross-References to Related Applications

This application claims the benefit of U.S. Provisional Application No. 60/432,162 filed December 10, 2002 the entire contents of which are herein incorporated by reference.

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Technical Field

This invention relates generally to couplings used in transferring a liquid substance from one reservoir in which a liquid is stored to a second reservoir. More particularly, the invention relates in one embodiment to couplings useful in transferring a liquid hydrocarbon fuel from a storage vessel to an on-board fuel tank inside a motorized vehicle, such as an automobile.

Background

By the very nature of the utilization of liquid substances such as liquid hydrocarbon fuels, it is frequently necessary to transfer a liquid fuel from a first storage vessel in which it is contained to a second storage vessel. One particular instance in which it is necessary to so transfer a liquid fuel is in the case of re-fueling an automobile during a racing event.

One particular class of automobile racing is where competing vehicles must travel an extended period of time to cover the pre-determined distance of the race. Such automobile races have been known since the advent of the automobile itself, and current NASCAR and other events include such races as the Indianapolis 500, the California 500,

the Virginia 500, New England 300, to name but a few. Such automobile races typically require drivers and their cars to travel hundreds of miles from start to finish. Quite often, such races are carried out on a track, which may be circular, oval, or which may trace out a serpentine course.

5 Since the fuel-carrying capacity of the race car is limited by the rules of racing to be of specific volume, and the capacity of such tanks is not sufficient to enable the racer to complete the entire race on a single tank load of fuel, it is a general requirement of modern automobile racing that drivers must stop their vehicles periodically to have their tanks re-charged with fuel. Since the nature of racing is such that the first racer to cross
10 the finish line is generally declared the winner, the amount of time used for the combined re-fueling operations becomes a significant factor in determining the outcome of any given race. Hence, it is essential from the standpoint of the racing team that the time utilized in re-fueling and other pit-stop operations is kept to an absolute minimum.

 The current state-of-the-art method for re-fueling a racing vehicle in a circle-track
15 application is for the racer to pull their car into an area known to those skilled in the art as the "pit-stop" for servicing. As is customary, the on-board fuel tank of a racing vehicle includes an inlet conduit through which fuel is admitted to the tank during re-fueling. There is also an exit conduit through which fuel is exited from the fuel tank and delivered by means of a fuel pump to the engine. There is also a cap or other means of sealing the
20 inlet conduit from the surrounding environment after a re-fueling of the vehicle is complete. There is a headspace volume above the liquid level of the fuel in the tank. Initially, when the tank is full, the headspace volume is at its minimum. As fuel is

consumed, the headspace volume increases, and reaches its maximum when all of the liquid fuel formerly contained in the tank has been consumed.

It is through the inlet conduit of the fuel tank that fuel is admitted during a pit-stop re-fueling operation. During a re-fueling, a member of the pit crew carries a large funnel-shaped vessel (the "recharging tank") which is full of a motor fuel, such as a gasoline. The recharging tank includes a fitting on its lower extremity which is complementary to that on the end of the inlet conduit on the fuel tank that is adapted to receive fuel. After the racer's vehicle comes to a stop, the pit crew will remove the cap from the fuel tank inlet conduit. Then, the fitting on the recharging tank is mated to the fitting on the inlet conduit to form a sealed conduit through which fuel may pass from the recharging tank to the on-board fuel tank of the race car. A valve disposed on the recharging tank is opened, and fuel contained within the recharging tank is caused to flow, by the force of gravity, from the recharging tank into the on-board fuel tank of the racing vehicle.

The re-fueling of a racing vehicle is undertaken in as quick a time as seems possible, and with minimizing the losses of fuel during the operation. However, one of the disadvantages of current re-fueling methods is that large volumes of gasoline are spilled onto the pavement and portions of the vehicle being re-fueled. A typical volume of fuel lost by spillage in re-fueling operations during the course of a race may be several gallons of fuel, which losses occur primarily when the recharging tank is removed from the inlet conduit. While pit crews are well-equipped to deal with inadvertent fires that may occasionally occur, there are immediate health risks to pit crew personnel other than the fire hazard. For example, modern racing engines are typically designed to have an

effective compression ratio in excess of 10:1, and these high compression ratio engines require fuels having high octane ratings. Volatile anti-knock compounds such as tetraethyl lead and the like are formulated into racing fuels as octane boosters. Since these lead compounds are volatile and since they are known health hazards, the issue of inhalation of tetraethyl lead and related compounds as a health hazard to pit crews is a serious matter. In addition, any un-necessary release of raw hydrocarbon fuels into the atmosphere is a public health concern as well. While professional racing has enjoyed exemption from many regulations applicable to automobiles driven on public roads, there exists a need in the art to minimize fuel spillage, while maintaining the rapidity at which a fuel tank on a racing vehicle may be re-filled.

Another issue for automobiles is the concept of vapor lock. Vapor lock is a condition which is manifest by the pressure in the headspace above the fuel in an on-board fuel tank being lower than normal atmospheric pressure. Such a condition is caused to exist by virtue of the fuel pump removing fuel from the fuel tank, without the same volume of air being admitted into the tank to compensate for the lost volume of fuel because the fuel tank is sealed off from the atmosphere. Eventually, the fuel pump is required to pump fuel from an area of reduced pressure, and, not being designed for such use, a less-than-desired amount of fuel is delivered to the engine, which results in inhibited engine performance.

Thus, it is an object of the present invention to provide a pair of coupling fittings, one which resides on the end portion of the fuel inlet conduit of an on-board fuel tank, the other residing on the lower end of a containment vessel in which a liquid hydrocarbon is stored.

It is a further object to provide such a pair of coupling fittings wherein the fittings are complementary to one another and may be connected and/or disconnected from one another in a minimal amount of time.

5 It is a further object still to provide such a pair of coupling fittings wherein the amount of fuel spillage resulting from the disconnection of each of the fittings from one another is kept to a minimum volume.

It is a further object still to provide such a pair of coupling fittings such as aforesaid wherein the charging of fuel from the storage vessel approaches the maximum physically allowable rate of speed.

10 It is a further object still to provide such a pair of coupling fittings such as aforesaid wherein the problems associated with the concept of vapor lock are eliminated from the system.

These objects are all simultaneously achieved by the present invention, as will become evident to one of ordinary skill in the art after reading and understanding the
15 contents of this specification and the appended claims.

Summary of the Invention

The present invention provides a fuel transfer coupling for attachment to the inlet pipe of a vehicle's fuel tank which comprises a base portion which comprises a planar top surface and which comprises a central bore portion having a first end portion and a second end portion, wherein the central bore portion is surrounded by a shrouding enclosure, wherein the shrouding enclosure includes a vapor tube, wherein the shrouding enclosure is in fluid communication with a plurality of holes disposed on the planar top surface, thus providing fluid communication between the holes and the vapor tube, the base portion further including a circumferential ledge at the terminus of the second end portion within the base portion, and wherein the base portion further comprises a flange disposed about its periphery, the flange including a plurality of holes in its surface. There is a flow control cone having an adjacent wall, the flow control cone including a spring seat, a poppet guide bore, an outer ring portion, and a wall portion, wherein the flow control cone is disposed at the second end portion of the central bore portion with its outer ring in contact with the circumferential ledge, thus forming a circumferential slot between the adjacent wall and the wall portion of the flow control cone. There is a poppet having a flat top surface, a bottom surface, and a stem, wherein the stem is slidably disposed within the poppet guide bore, the poppet further comprising a vent disc centrally disposed on the flat top surface, wherein the vent disc is mechanically biased towards the flat top surface. There is a spring disposed between the spring seat and the bottom surface of the poppet. There is a hollow internal housing having a flat top surface and a skirt portion, the internal housing being disposed about the poppet and wherein the

the skirt of the internal housing is slidably disposed within the circumferential slot.

There is an adapter cover affixed to the base portion, in which is contained the flow control cone, the poppet, the spring, and the internal housing, wherein the adapter cover further includes a substantially cylindrically-shaped outer wall portion and a flange
5 comprising a plurality of holes for fastening the flange of the cover to the flange of the base portion.

The invention also provides an automobile including a fuel tank having an inlet pipe and further comprising the coupling described above wherein the vapor tube is in effective fluid contact with the headspace above the fuel in the fuel tank and wherein the
10 first end portion of the central bore portion is in effective fluid contact with the inlet pipe.

The invention also provides a fuel transfer coupling for attachment to a source of fuel to be delivered to a vehicle's fuel tank which comprises a base portion which comprises a raised surface and which comprises a central conduit portion having a top end portion and a bottom end portion, wherein the central conduit portion is surrounded
15 by a shrouding enclosure, wherein the shrouding enclosure includes a vapor tube and wherein the shrouding enclosure is in fluid communication with a plurality of holes disposed on the raised surface, thus providing fluid communication between the holes and the vapor tube. The base portion further includes a flange disposed about its periphery, the flange including a plurality of holes in its surface. There is a boss centrally
20 located within the central conduit portion, the boss adapted to receive and rigidly hold in place a fastener means. There is a spring disposed about the top end portion of the central conduit portion. There is a collar/seal ring assembly which itself comprises:

i) a moveable collar shaped substantially in the form of a cylindrical sleeve having a top portion, a bottom portion, and a circumferential wall and comprising a plurality of slots in its wall; and ii) a seal ring having a flat top surface and being disposed within the inner space defined by the wall of the moveable collar, being held in position therein by means of a plurality of equatorially-located protrusions extending from the seal ring into the plurality of slots on the moveable collar, the plurality of slots further including springs for mechanically biasing the seal ring in a direction towards the top portion of the moveable collar in which it is disposed. The collar/seal ring assembly is in contact with the spring. There is also a valve center having a flat top portion and a stem portion having a tip, wherein the tip of the valve center includes a means for receiving a fastener means, wherein the means for receiving a fastener means is mechanically engaged with the fastener means in the boss. There is also an adapter cover shaped substantially in the form of a cylindrical sleeve affixed to the base portion, in which is contained the spring, the collar/seal ring assembly, and the valve center, wherein the adapter cover includes a smooth bore in its inner wall, and wherein the bottom includes a plurality of holes for fastening the cover to the flange of the base portion.

In another aspect, the present invention comprises a quick-detach fuel transfer coupling through which a liquid fuel may pass from a remote charging reservoir to a vehicle's on-board fuel tank which comprises an on-board portion having an inlet end and a discharge end, wherein the discharge end is in fluid communication with the inlet pipe of a vehicle's on-board fuel tank. The on-board portion comprises a substantially-cylindrically shaped first adapter portion comprising an outer wall disposed about a central bore, and the outer wall has a central axis. There is a means for permitting a

liquid fuel to pass into the fuel tank via a path which is annularly disposed about the central axis. There is also a means for permitting vapor from within the fuel tank to exit the fuel tank via a path which is annularly disposed about the central axis. There is a remote portion having an inlet end and a discharge end, and the inlet end is in fluid communication with the contents of a remote charging reservoir. The remote portion comprises a substantially-cylindrically shaped second adapter portion comprising a smooth bore disposed about a central bore, and the smooth bore has a central axis. There is a means for permitting flow of a liquid fuel from the remote charging reservoir to the on-board portion upon placement of the smooth bore over the outer wall via a path which is annularly disposed about the central axis. There is a means for permitting vapor from within the fuel tank to enter the remote charging reservoir via a path which is annularly disposed about the central axis. In this aspect of the invention, it is preferred that the central axis of said first adapter coincides substantially with said central axis of said second adapter.

Brief Description of the Drawings

In the annexed drawings:

5 **FIG. 1** shows a an exploded perspective view of the on-board portion of a fuel coupling according to one form of the invention;

FIG. 2 shows a perspective view of the male adapter base portion of the on-board portion of a fuel coupling according to one form of the invention;

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FIG. 3 shows an overhead view of the male adapter base portion of the on-board portion of a fuel coupling according to one form of the invention;

15 **FIG. 4** shows a perspective view of the male adapter cover of the on-board portion of a fuel coupling according to one form of the invention;

FIG. 5 shows a side elevation view of the male adapter cover of the on-board portion of a fuel coupling according to one form of the invention;

20 **FIG. 6** shows a bottom view of the male adapter cover of the on-board portion of a fuel coupling according to one form of the invention;

FIG. 7 shows a perspective view of the internal housing portion of an on-board portion of a fuel coupling according to one form of the invention;

FIG. 8 shows a side elevation view of the internal housing portion of an on-board portion
5 of a fuel coupling according to one form of the invention;

FIG. 9 shows a perspective view of a flow control cone element of an on-board portion of a fuel coupling according to one form of the invention;

10 **FIG. 10** shows a side-elevation view of a flow control cone element of an on-board portion of a fuel coupling according to one form of the invention;

FIG. 11 shows an overhead view of a flow control cone element of an on-board portion of a fuel coupling according to one form of the invention;

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FIG. 12 shows a perspective view of the bottom side of a flow control cone element of an on-board portion of a fuel coupling according to one form of the invention;

FIG. 13a shows a perspective view of the upper portion of a poppet element of an on-
20 board portion of a fuel coupling according to one form of the invention;

FIG. 13b shows a side elevation view of the upper portion of a poppet element of an on-board portion of a fuel coupling according to one form of the invention;

FIG. 14 shows a perspective view of the bottom side of a poppet element of an on-board portion of a fuel coupling according to one form of the invention;

FIG. 15 shows a bottom view of a poppet element of an on-board portion of a fuel
5 coupling according to one form of the invention;

FIG. 16 shows a side view of the assembled male adapter portion ("on-board portion") of a coupling pair according to the invention;

10 **FIG. 17** shows top view of the assembled male adapter portion of a coupling pair according to the invention;

FIG. 18 shows a perspective view of the top portion of an assembled male adapter portion of a coupling pair according to the invention;

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FIG. 19 shows a perspective view of the underside portion of an assembled male adapter portion of a coupling pair according to the invention;

FIG. 20 shows a perspective view of the underside portion of an assembled male adapter
20 portion of a coupling pair according to the invention;

FIG. 21 shows perspective view of the top portion of an assembled male adapter portion of a coupling pair according to the invention;

FIG. 22 shows a bottom view of an assembled male adapter portion of a coupling pair according to the invention;

FIG. 23 shows an exploded perspective view of the remote (or "female") portion of a fuel
5 coupling according to one form of the invention;

FIG. 24 shows a side elevation view of the female adapter base portion of the remote portion of a fuel coupling according to one form of the invention;

10 **FIG. 25** shows a perspective view of the upper portion of the female adapter base portion of the remote portion of a fuel coupling according to one form of the invention;

FIG. 26 shows a top view of the female adapter base portion of the remote portion of a fuel coupling according to one form of the invention;

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FIG. 27 shows a perspective view of a female adapter cover portion of the remote portion of a fuel coupling according to one form of the invention;

FIG. 28 shows a top view of the female adapter cover portion of the remote portion of a
20 fuel coupling according to one form of the invention;

FIG. 29 shows a bottom view of the female adapter cover portion of the remote portion of a fuel coupling according to one form of the invention;

FIG. 30a shows a perspective view of the moveable collar portion of the remote portion of a fuel coupling according to one form of the invention;

FIG. 30b shows a side elevation view of the moveable collar portion of the remote
5 portion of a fuel coupling according to one form of the invention;

FIG. 31 shows an overhead view of the moveable collar portion of the remote portion of a fuel coupling according to one form of the invention;

10 **FIG. 32** shows a bottom view of the moveable collar portion of the remote portion of a fuel coupling according to one form of the invention;

FIG. 33 shows a perspective view of the bottom portion of the moveable collar portion of the remote portion of a fuel coupling according to one form of the invention;

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FIG. 34 shows a perspective view of the seal ring element of the remote portion of a fuel coupling according to one form of the invention;

FIG. 35 shows a side elevation view of the seal ring element of the remote portion of a
20 fuel coupling according to one form of the invention;

FIG. 36 shows an overhead view of the seal ring element of the remote portion of a fuel coupling according to one form of the invention;

FIG. 37 shows a perspective view of the assembled collar/seal ring assembly element combination of the remote portion of a fuel coupling according to one form of the invention;

5 **FIG. 38** shows a side elevation view of the assembled collar/seal ring assembly element combination of the remote portion of a fuel coupling according to one form of the invention;

FIG. 39 shows an overhead view of the assembled collar/seal ring assembly element
10 combination of the remote portion of a fuel coupling according to one form of the invention;

FIG. 40a shows a top view of the valve center element of the remote portion of a fuel coupling according to one form of the invention;

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FIG. 40B shows a bottom perspective view of the remote portion of a fuel coupling according to one form of the invention;

FIG. 40C shows a side elevation view of the remote portion of a fuel coupling according
20 to one form of the invention;

FIG. 41 shows a side view of the assembled female adapter portion of a coupling pair according to the invention;

FIG. 42 shows a bottom view of the assembled female adapter portion of a coupling pair according to the invention;

FIG. 43 shows a top view of the assembled female adapter portion of a coupling pair
5 according to the invention;

FIG. 44 shows a perspective view of the inside of the top portion of an assembled female adapter portion of a coupling pair according to the invention;

10 **FIG. 45** shows a perspective view of the inside of the top portion of an assembled female adapter portion of a coupling pair according to the invention;

FIG. 46a-f shows a cross sectional view of a coupling pair according to a preferred form of the invention, at various stages of coupling and de-coupling of the pair encountered
15 during a typical refueling operation;

FIG. 47 shows a perspective view of a fuel reservoir having a coupling according to one form of the invention attached thereto; and

20 **FIG. 48** shows a perspective view of a remote fuel reservoir having a coupling according to one form of the invention attached thereto.

Detailed Description

A fuel transfer coupling according to the present invention comprises an on-board portion which is in fluid contact with the gasoline tank on a motorized vehicle such as a race car, and a remote portion which is in fluid contact with a source of liquid hydrocarbon fuel that is to be delivered to the gasoline tank of the motorized vehicle. The on-board portion may be referred to as the male adapter and the remote portion of the coupling may be referred to as the female adapter, for convenience.

Referring to the drawings, and initially to **FIG. 1** there is shown the on-board portion of a fuel transfer coupling according to the invention in an exploded view, including all of its various components, which are described forthwith.

In **FIG. 2** is shown a perspective view of the male adapter base **4**. The male adapter base **4** includes a central bore **34** through which fuel is intended to flow. The central bore **34** has a first end portion which is adapted to be connected to the inlet pipe of a fuel tank, and a second end portion which extends into said adapter base and terminates at a point within the male adapter base. Disposed about the central bore **34** is a shrouding enclosure **36** which forms an envelope around the central bore portion **34** for the purpose of allowing the travel of gas or air vapor through the various holes **33** disposed in the planar top surface **40** of the male adapter base, wherein the holes **33** are in fluid contact with the outlet portion **35** of the vapor tube **20**. Thus, this assembly is similar to a condenser as used in the chemical arts, which consists of a tube having a water jacket about it, with an inlet and outlet for the cooling water, and a tube disposed therethrough which the vapor to be condensed is caused to pass. In the present instance,

the central bore 34 is surrounded by the shrouding enclosure 36, which has as its "inlet", the various holes 33, and which has as its "outlet", the vapor tube 20. There is a planar flange portion 42 having a plurality of holes 44 disposed through it along its periphery for the purpose of fastening the male adapter base to other components of this portion of the coupling. The plane of the flange portion 42 is slightly below the plane of the top surface 40, and at the point of intersection of these two features there is thus caused to exist an elevation 38, upon which an o-ring seal may be mounted for sealing the surfaces in the finished assembly. There is a circumferential ledge 37 onto which a flow cone 58 is mounted, as is described later herein. The wall W of the bore above the circumferential ledge 37 is also shown.

In FIG. 3 is shown an overhead view of the male adapter base 4, including the central bore 34 flange 42, holes 44, vapor tube 20, holes 33, circumferential ledge 37, and o-ring seal 46 in its location at the elevation at 38 as shown in FIG. 2.

FIG. 4 shows a perspective view of the male adapter cover 2, having an outer wall 24, top surface 3, and flange portion 26, wherein the flange portion 26 includes a plurality of holes 28 disposed along its periphery for connection to the male adapter base 4 once all of the components have been properly assembled, using conventional fasteners. There is also a beveled edge 30, which is shown in FIG. 6 as well.

FIG. 5 shows a side elevation view of the male adapter cover 2, including outer wall 24 and flange 26.

FIG. 6 shows a bottom view of the male adapter cover 2, including its flange 26, plurality of holes 28, annular groove 19 which extends about the hole 1 adjacent to the

flange 26 and is adapted to receive the o-ring seal 46 in a sealing relationship in the completed assembly. There is also a beveled edge 30.

FIG. 7 shows the internal housing 18, which is reminiscent of a hollow shell having an open top portion **T** and an open bottom portion **B**, and a hollow interior space within the confines of its walls. There is a flat top surface 48, a sloping shoulder portion 49 which includes an o-ring seal 50, which o-ring seal 5 is disposed to seal between the sloping shoulder 49 and the beveled edge 30 from **FIGS. 4** and **6** previously. There is also an o-ring seal 52 disposed along the bottom skirt portion 51 as well, for sealing the skirt portion 51 against the wall portion **W** of the bore in **FIG. 2**. Thus, the skirt portion 51 of the internal housing 18 is slidably disposed within a circumferential slot which is defined by the wall **W** that is adjacent to the circumferential ledge 37 and the wall portion 64 of the flow control cone 6 when the flow control cone is in its position on the circumferential ledge 37. The skirt portion 51 provides a travel stop against planar top surface 40.

FIG. 8 shows a side elevation view of the internal housing 18 and depicts the locations of the top surface 48, sloping shoulder 49, o-ring seal 50, skirt 51, and o-ring seal 52.

FIG. 9 shows a perspective view of the flow control cone 6 component. The flow control cone 6 includes a funnel-shaped cone element 58, which is held rigidly in place in the center of an outer ring 62 (which has a wall portion 64) by means of cone supports 60 which are welded or otherwise attached by known conventional means, such as integral casting, etc., to the cone and inner portion of the wall portion 64 of the outer ring 62.

There is also a poppet guide bore **54** disposed at the apex of the cone, and a space **59** disposed between the cone **58** and the outer ring **62**.

FIG. 10 is a side elevation view of the flow control cone **6** showing the cone **58**, wall portion **64**, and the outer ring **62**. The cone supports **60** are also shown.

5 **FIG. 11** shows a bottom view of the flow control cone **6** showing the poppet guide bore **54**, wall portion **64**, outer ring **62**, cone supports **60**, space **59**, and cone **58**. The diameter of the wall portion is slightly less than that of the internal diameter of the bottom portion **B** of the internal housing **18** shown in **FIG. 7**, which enables the skirt portion **51** of the internal housing to reside atop the outer ring **62** of the flow control
10 cone **6** after the flow control cone **6** has been placed in position on the circumferential ledge **37** of **FIG. 2**.

FIG. 12 shows a perspective view of the top of the flow control cone **6** including the poppet guide bore **54** having an outer wall **56**. There is a flat portion **57** which serves as the seat for the poppet spring **8** (**FIG. 1**). Also shown is cone **58**, cone supports **60**,
15 outer ring **62**, and wall portion **64**.

FIG. 13A shows a perspective view of the upper portion of the poppet **10** which includes a flat top surface **70**, and an o-ring seal **72** disposed on the upper shoulder **80** (**FIG. 13B**). There is a poppet stem **68** which is preferably of a tri-lobe cross-section as later shown. There is a vent disc **14** disposed in a recess in the face of the flat top surface
20 **70**, which is held in place by retainer ring **16**, which retainer ring **16** is held in position by means of machine screws threaded through the flat top surface. The vent disc **14** in one embodiment includes a hole **15** that passes through the vent disc. The spring **12**

mechanically biases the disc 14 onto its seat. According to an alternate form of the invention, the hole 15 may be disposed through the wall of the male adapter cover 2.

FIG. 13B is a side elevation view of the poppet 10, showing the upper shoulder 80 of the poppet 10, lower shoulder 81 of the poppet 10, o-ring seal 72, and poppet stem 68.

FIG. 14 shows a perspective view of the underside of the poppet 10 which includes the lower shoulder 81, flat bottom surface 83, o-ring seal 72, vent disc 14 having hole 15, spring 12, machine screw bottoms 78, poppet stem 68, and stem supports 69. The spring 12 is disposed between the vent disc 14 and the poppet stem 68 so as to maintain a mechanical bias on the vent disc 14 in a direction towards the flat top surface 70 from **FIG. 13A**.

FIG. 15 shows a bottom view of the poppet 10 including the stem supports 49, poppet stem 68, vent disc 14, lower shoulder 81, and flat bottom surface 83. The circle labeled **D1** is of such a diameter as to be just slightly larger than the diameter **D2** of the top portion of the cone 58 (**FIG. 10**) so that the skirt of the poppet 81 lines up with the top portion of the cone 58 to promote a smooth fuel flow. The poppet stem 68 is of such diameter as to form a snug fit which allows in and out motion of the poppet within the poppet guide bore 54.

FIG. 16 shows a side view of the male adapter 700 in its final assembled form, when all of the components shown in **FIG. 1** and as previously described herein are contained within the male adapter cover 2 and the male adapter base in their proper design configuration. To assemble the male adapter 700, one begins by placing the male adapter base 4 on a flat surface. Next, the flow cone 6 is placed into position so that the

outer ring 62 of the flow cone 6 rests on the circumferential ledge 37, so that the poppet spring seat 57 is facing upwards, as shown in FIG. 1. Next, the poppet 10 (including the spring 12, vent disc 14, and retaining ring 16) is inserted into the internal housing 18 from the bottom B (FIG. 8) so that the o-ring seal 72 contacts the inner wall of the internal housing 18 at a location on the interior of the sloping shoulder 49, which is a bevel 99 shown in FIG. 7 that extends around the inner circumference of the internal housing so as to completely contact the o-ring seal 72. Next, the poppet spring 8 is placed on the spring seat 57, and the internal housing 18 (with poppet 10 inside it) is then placed into position so that the skirt portion 51 rests atop the outer ring portion 62 of the flow control cone 6, against the pressure of the poppet spring. Finally, the male adapter cover 2 is placed over the internal housing and the fasteners are secured to connect the flanges on the male adapter cover 2 and the male adapter base 4, to provide the assembled male adapter 700 as shown in FIG. 16.

FIG. 17 shows a top view of the assembled male adapter 700, showing the respective positions of the vent disc 14, vent hole 15, retaining ring 16, vapor tube 20, flange 26, flat top surface 48 of the internal housing 18, flat top surface 70 of the poppet 10, top surface 3 of the male adapter cover 2 (FIG. 4), and the important gap 7 between the outer perimeter of the flat top surface 48 of the internal housing 18 and the inner perimeter of the top surface 3 of the male adapter cover 2. The gap 7 is important, as it is through this gap that air passes during a refueling operation, to allow the escape of headspace air in the fuel tank to compensate for the volume of fuel delivered during the refueling operation. As the flat top surface 70 of the poppet is depressed slightly, at first, against the pressure of the poppet spring 8, both the poppet 10 and the internal housing

18 move into the assembly as a whole, until the skirt portion 51 has bottomed out against the face 40 of the body 4. The movement of the internal housing 18 to its bottomed out position opens a space in the gap at 7 between the inner wall of the male adapter 2 and the internal housing 18 by releasing the contact between the o-ring seal 50 and the
5 beveled edge 30. This slight depressing of the flat top surface 48 of the internal housing 18 causes a fluid connection to exist between the vapor tube 20 and the gap 7 at the top portion of the assembly where the o-ring seal 50 has separated from the beveled edge 30, through the plurality of holes 33 in the male adapter base 4.

Further depressing of the flat top surface 70 of the poppet 10 opens a space S
10 between the outer periphery of the top surface 70 of the poppet 10 and the internal wall of the internal housing 18, as shown in FIG. 18, thus enabling a liquid fuel to pass through the inner volume of the internal housing, through the open space 59 in the flow control cone 6 and through the central bore 34, which is connected to the inlet pipe on the vehicle's fuel tank. The vapor tube 20 is connected to a hose which is in fluid contact
15 with the headspace gas within the fuel tank. Thus, by depressing the flat top surface 70 of the poppet 10, a fluid communication between the headspace gas in the fuel tank and the gap at 7 is first caused, and secondly a pathway is opened to the fuel tank for fuel to flow in through central bore 34, from a location at the top of the poppet in the closed condition. This is because the poppet spring 8 biases the poppet upwards; however, the
20 poppet 10 is located within the internal housing 18 but the head of the poppet has a larger diameter than the diameter of the beveled edge 99 just beneath the top surface 48 of the internal housing 18 in which it is contained, which thus also causes the internal housing 18 to be biased upwards. The internal housing 18 is held in position within the male

adapter cover 2 because the diameter of the sloping shoulder 49 of the inner housing 18 is larger than that of the beveled edge 30 in the male adapter cover. This is why the male adapter assembly 700 can only be assembled as taught herein.

5 **FIG. 19** shows the underside view of the male adapter assembly 700 when the poppet 10 is not depressed, and **FIG. 20** shows the underside view of the assembly 700 while the poppet 10 is depressed, showing the movement of the poppet stem 69 with respect to the outer wall 56. **FIG. 21** is a top perspective view of the male adapter assembly 700, and **FIG. 22** is a bottom view of the male adapter assembly 700.

10 A fuel transfer coupling according to the present invention comprises a remote portion which is in fluid contact with a source of liquid hydrocarbon fuel that is to be delivered to the gasoline tank of the motorized vehicle. The remote portion may be thought of as a female adapter owing to its being adapted to receive the male portion of the coupling already described herein. The female adapter, in one preferred form of the invention, is preferably disposed at the exit point of a fuel from a portable, remote fuel
15 reservoir.

Referring to the drawings, and particularly to **FIG. 23** there is shown the remote portion of a fuel transfer coupling according to the invention in an exploded view, including all of its various components, which are described forthwith.

20 **FIG. 24** shows a side elevation view of a female adapter base 164 according to the invention, including the top portion of the central conduit 166T, bottom portion of the central conduit 166B, shrouding enclosure 170 vapor tube 172, o-ring seal 168, and raised surface 171.

FIG. 25 shows a perspective view of the upper portion of the female adapter base **164** according to the invention, including the raised surface **171**, shrouding enclosure **170**, outer flange **180** having a plurality of holes **182** disposed thereon, holes **174**, vapor tube **172**, top portion of the central conduit **166T** having a flat top surface **184**, o-ring seal **168**, and a retaining fastener **176** disposed in a boss **177** held centrally within the interior of the central conduit by means of a plurality of fastener boss supports **178**, which are affixed to the inner surface of the wall of the central conduit by conventional means, such as a weld. Retaining fastener **176** is shown with its threads visible.

FIG. 26 shows a top view of the female adapter base **164** according to the invention, including the central conduit, raised surface **171**, holes **174**, vapor tube **172**, top surface **184**, flange **180**, holes **182**, fastener boss supports **178** and retaining fastener **176**. Thus, the female adapter base **164** includes a central conduit **166** through which fuel is intended to flow. Disposed about the central conduit is a shrouding enclosure **170** which forms an envelope around the central conduit for the purpose of allowing the travel of gas or air vapor through the various holes **174** disposed in the raised surface **171** of the female adapter base, wherein the holes **174** are in fluid contact with the outlet portion **187** of the vapor tube **172**. Thus, this assembly is similar to a condenser as used in the chemical arts, which consists of a tube having a water jacket about it, with an inlet and outlet for the cooling water, and a tube disposed therethrough which the vapor to be condensed is caused to pass. In the present instance, the central conduit is surrounded by the shrouding enclosure **170**, which has as its "inlet", the various holes **174**, and which has as its "outlet", the vapor tube **172**.

FIG. 27 shows a perspective view of a female adapter cover **144** according to the present invention, which is shaped in the form of a hollow cylindrical shell, reminiscent of a cylinder sleeve. The female adapter cover includes a smooth bore **196** along its length dimension, except for a raised band **194** at the top, which raised band has a slightly less inner diameter than the smooth bore **196**. There is an o-ring seal **148** which is disposed in an annular slot at the upper end of the female adapter cover, which o-ring provides a seal around the outer surface of the male adapter cover **2** when the male adapter cover is inserted into the female adapter cover **144**. There is a top surface **146** and a flared bottom **150**.

FIG. 28 shows a top view of the female adapter cover **144**, including the top surface **146** and the o-ring seal **148**.

FIG. 29 shows a bottom view of the female adapter cover **144**, including flared bottom **150** and a plurality of threaded holes **152** disposed circumferentially about the lower flared portion, which holes are adapted to receive a fastener that also passes through the holes **182** in the female adapter base **164**, which are in the same configuration and spacing on both the female adapter cover **144** and female adapter base **164**. The diameter **D3** of the inner bore **196** of the female adapter cover **144** is just slightly larger than the diameter of the raised surface **171**, so that the female adapter cover **144** may be securely fit over the female adapter base **164**.

FIG. 30a shows a moveable collar **102** according to the present invention, which is shaped as a hollow cylinder. The moveable collar **102** is intended to be slidably disposed within the smooth bore **196** of the female adapter cover **144**. The moveable collar **102** includes a groove **108** in which is housed an o-ring seal **130**, which o-ring

seals the outer surface of the moveable collar 102 within the smooth bore 196 of the female adapter cover 144. There is a flat top surface 106, and a plurality of slots 104 which pass through the wall of the moveable collar and may thus be regarded as holes. On the inside wall of the moveable collar 102, there is a flat recessed surface 112 that is disposed between beveled edge 114 and bevel 110. Surface 113 extends annularly about the inside diameter of the moveable collar 102, and has itself an inside diameter which is smaller than the inside diameter of the flat recessed surface 112. The surface 115 extends annularly about the inside diameter of the moveable collar 102 and has its own inside diameter which is less than that of surface 113. Thus, going from surface 113 to surface 112, there is a bevel 110. Then, going from surface 112 to surface 115, there is a beveled edge 114.

FIG 30b shows a side elevation view of the moveable collar 102 element of the invention, including the slots 104, flat top surface 106, and groove 108.

FIG. 31 is a top view of the moveable collar 102 element of the invention, including the flat top surface 106.

FIG. 32 shows a bottom view of the moveable collar 102 element of the invention, including the beveled edge 114 and holes 117 which are drilled from the bottom surface of the moveable collar to the floor portion of each of the slots 104, so as to enable insertion of springs into the holes 117.

FIG. 33 shows a perspective view of the bottom of the moveable collar 102, including the slots 104 and groove 108. There is also shown surface 115, beveled edge 114, holes 117, surface 112, surface 113, flat surface 119, wall 203, and flat surface 201. The flat surface 119 accommodates a retaining ring 190 (**FIG. 23**) having same diameter

as said flat surface 119, to retain in their position springs which have been placed into the holes 117. The springs are then held in place by a retaining ring fastened to flat surface 119, either by interference fit, an adhesive substance, or other conventional means. There is also a flat bottom surface 201.

5 **FIG. 34** shows a seal ring 116 element of the invention, which is preferably metallic in construction, as are all of the other elements of the couplings of the present invention. The seal ring includes a hollow interior space 207. There is a flat top surface 118 which includes an o-ring seal embedded in an annular groove that is present on the flat top surface 118. There is a beveled surface 132, which is reminiscent of a valve-seat
10 in an automotive cylinder head, and which beveled surface functions as a seat for the valve center 154 as later described herein. There is a shoulder portion 120 which includes an o-ring seal 122 annularly disposed thereon. There is also a lower shoulder 134, and a skirt portion 128, as well as a smooth bore 312. These elements are shown in **FIG. 35** as well, in addition to threaded holes 126 which are drilled into the seal ring 116
15 at a band portion 124 which circumscribes the seal ring. There are a plurality (preferably 4) of holes 126 spaced around the perimeter of the seal ring 116 which correspond in position to the slots 104 in the moveable collar 102. The centerlines of the bores of the threaded holes 126 are perpendicular to the centerline of the seal ring 116 itself. There is also a flat portion 192 on the underside of the seal ring which functions as a seat for the
20 spring 186 (**FIG. 23**).

FIG. 36 is a top view of the seal ring 116, showing the respective positions of the beveled surface 132, flat top surface 118, o-ring seal 130, shoulder 120, and o-ring 120.

FIG. 37 shows the collar/seal ring assembly **136**. According to the invention, the seal ring **116** is moveably held in place within the moveable collar **102**. This is done by first inserting a spring **140** into each of the holes **117** in the underside of the moveable collar **102**, and then securing them in place by placement of spring retaining ring **190** (**FIG. 23**) onto the flat surface **119**, such as by using an epoxy resin. This causes the springs to be partly visible in the slots **104** and partially embedded within the hole **117** between the bottom of the moveable collar and the bottom of the slots **104**. A slight forcing of the springs **140** downward enables one to insert a screw **138** (whose threads match the holes **126** on the outer band of the seal ring **116** into the slot between the top of the spring **140** and the top portion of the oval or elongate slot **104**. When four screws are inserted into the four slots **104** in such fashion, the seal ring **116** may then be placed into the interior of the moveable collar **102** so that the four screws **138** are engaged in the threads in the holes **126**. A more preferred means for assembly is to first assemble o-ring **122** to seal ring **116**. Subsequently, the seal ring **116** is fitted inside the moveable collar **102**, and then the screws **138** are inserted through the slots in the moveable collar **102** into threaded holes **126** in **116**. Then the springs **140** are inserted into the holes **117** and the retainer **190** is fitted into the groove in the moveable collar **102**. Such a construction yields the arrangement shown in **FIG. 37** in which the seal ring **116** is held within the moveable collar **102** in such fashion that motion of the seal ring **116** within the moveable collar **102** is permitted in the direction of the centerline, but downward, and against the pressure of the springs **140** applied on each of the screws **138**. Such a motion downwards pushes the seal ring **116** downward, releasing the contact between the o-ring **122** and the beveled edge **114**, thus opening up an annular space located at the gap at **142**.

Upon release of downward pressure on the seal ring 116, the force of the springs 140 force the seal ring 116 back in an upwards direction, forcing the o-ring 122 to sealably engage the beveled edge 114. Also shown in FIG. 37 is the flat top surface 106, flat top surface 118, o-ring seal 130, beveled surface 132, and o-ring seal 188 disposed in groove 5 108. Although the screws 138 are used to secure the seal ring 116 in its position within the moveable collar 102, any other functionally equivalent equatorially-located protrusions from the seal ring are suitable for use in this regard, including without limitation, pins welded into place.

FIG. 38 shows a side view of the collar/seal ring assembly 136, showing the 10 respective positions of the flat top surface 118, flat top surface 106, groove 108, springs 140 and screws 138. The bottom of the assembly is denoted as B.

FIG. 39 shows an overhead view of the collar/seal ring assembly 136, showing the respective positions of the flat top surface 118, o-ring 130, gap 142, flat top surface 106, and beveled surface 132.

15 FIG. 40A shows a top view of the valve center 154 of the present invention having a flat top surface 156.

FIG. 40B shows a perspective view of the underside of valve center 154 of the present invention, showing the stem portion 158 which has a threaded hole 160 at its bottom portion and an o-ring seal 162 disposed annularly about the valve center.

20 FIG. 40C shows a side perspective view of the valve center element 154, showing the respective positions of the stem 158 and o-ring seal 162 and flat top surface 156.

FIG. 41 shows a side view of the female adapter **701** in its final assembled form, when all of the components shown in **FIG. 23** and as previously described herein are contained within the female adapter cover **144** and the female adapter base **164** in their proper design configuration. To assemble the female adapter **701**, one begins by placing the female adapter base **164** on a flat surface so that the bottom of the central conduit **166B** and vapor tube **172** rest on the flat surface. Next, the spring **186** is placed in position around the top portion of the central conduit **166T** and using the flat surface **171** as a seat. Next, an o-ring **188** is placed in the groove **108** of the collar/seal ring assembly **136**, and the collar/seal ring assembly is located over the spring. The assembly **136** is pushed against the pressure of the spring **186** so that the top portion of the central conduit **166T** enters the underside of the assembly **136** and pushing is continued until the bottom skirt portion (**B** in **FIG. 38**) of the assembly **136** contacts the surface **171**, which simultaneously engages the o-ring **168** in a sealing contact with the smooth bore **312** in **FIG. 34**. Once the bottom portion **B** has contacted the surface **171**, the hole **160** in the end of the stem of the valve center is then threaded over the nut (retaining fastener **176**, **FIG. 25**) securely, so that subsequent releasing of the assembly **136** causes the beveled edge **132** to contact the o-ring **162** on the valve center **154** in a sealing arrangement. The female adapter cover **144** is then slid over the assembly **136** and fastened into position using conventional fasteners threaded through the holes **182** (**FIG. 25**) and into the threaded holes **52** (**FIG. 29**).

FIG. 42 is a bottom view of the assembled female adapter **701** showing the respective positions of the flange **180**, bolt holes **182**, retaining fastener **176**, fastener

boss supports 178, valve center 154, central conduit 166, vapor tube 172, and the outlet portion 187 of the vapor tube 172.

FIG. 43 is a top view of the assembled female adapter 701 showing the respective positions of its various elements including the top surface 146, flat top surface 118, o-ring 130, flat top 156, gap 142, and flat top surface 106.

FIG. 44 shows a perspective view of the inside top portion of the assembled female adapter 701 showing the respective positions of its various elements including the flat top surface 118, o-ring 130, flat top 156, top surface 146, flat top surface 106, and gap 142.

FIG. 45 shows a perspective view of the inside top portion of the assembled female adapter 701 in which the surface 118 has been pressed downward, against the force of spring 186 (FIG. 23) showing the respective positions of its various elements including the flat top surface 118, o-ring 130, flat top 156, top surface 146, flat top surface 106, gap 142, and opening O which has been caused to exist by virtue of the collar/seal ring assembly having been depressed against the force of spring 186 (FIG. 23).

The construction so described for the female adapter (or remote portion of a fuel transfer coupling according to the invention) operates as follows. A force is applied to the surface 118 of the collar/seal ring assembly, against the pressure of the spring 186. this causes the collar/seal ring assembly 136 to be moved inside the smooth bore 196 of the female adapter cover 144, to open up an opening O through which a fuel may flow by virtue of the beveled surface 132 having moved away from the o-ring seal 162 of the valve center 154. The collar/seal ring assembly continues its travel downwards opening

up the opening **O** larger and larger until the bottom portion **B** of the assembly **136** contacts the raised surface **171**. At this point, further pressure on surface **118** causes the seal ring **116** to continue moving downwards, against the pressure of springs **140**, which opens up the gap **142** by virtue of the o-ring seal **122** no longer being in contact with
5 beveled edge **114**. The opening of the gap **142** opens fluid communication between the outlet portion **187** of the vapor tube **172** and the gap **142**, through the holes **174** and shrouding enclosure **170**.

Reference is now made back to the male adapter **700**. When the male adapter **700** is engaged inside the female adapter cover and the two are pressed together by an applied
10 force, a series of events heretofore unknown in the art occurs. The o-ring **130** on the female adapter **701** contacts the flat top surface **48** of the internal housing **18**. The applied force causes the internal housing **18** to be pressed into the adapter **700**, thus opening the gap **7**, which provides a fluid communication path between the outlet portion **35** of the vapor tube **20** and the gap **7**. Continued applied force causes the assembly **136**
15 to be pushed into the smooth bore **196** of the female adapter cover **144**, thus creating an opening **O** through which a liquid fuel may flow as was shown in **FIG. 45**. Continued applied force opens the gap **142** by virtue of the assembly **136** bottoming out on the flat surface **171**, as described above, thus providing a fluid communication path between the outlet portion **187** of the vapor tube **172** and the gap **142**. Under such an arrangement,
20 the gap **7** of the male adapter **700** and the gap **142** of the female adapter **701** are in fluid contact, which also means that the outlet portion **35** of the vapor tube **20** and the outlet portion **187** of the vapor tube **172** are now in fluid communication with one another. During the course of the applied force, and more or less simultaneously with the afore

said events, the flat top **156** of the valve center **154** pushes on the flat top surface **70** of the poppet **10** thus opening space **S** as described for **FIG. 18**, thus enabling fluid contact between the space **S** on the adapter **700** and the opening **O** (**FIG. 45**) of the adapter **701**. Establishment of a fluid connection between the opening of space **S** and the opening **O**
5 means that there is now a fluid connection between the bottom of the central conduit **166B** and the central bore **34** of the male adapter base **4**. Thus, insertion of the outer surface of the male adapter cover **2** of the finished assembly **700** into the bore of the female adapter cover **144** of the finished assembly **701** simultaneously causes a fluid connection to occur between the vapor tubes of each of the coupling counterparts and a
10 fluid connection to occur between the central bore **34** of the male adapter base and the bottom of the central conduit **166B**.

According to a preferred form of the invention, the central bore **34** (**FIG. 2**) of the assembly **700** is connected by conventional means such as a hose to the inlet pipe through which a fuel tank is normally filled, and the outlet portion **35** of the vapor tube **20** is
15 connected by conventional means such as a hose to the headspace above the fuel in a fuel tank, and the assembly **700** is placed in a location at which the orifice through which gasoline is normally added to a vehicle's gas tank is located. The adapter assembly **701** is fitted to the bottom of a portable fuel reservoir (or the outlet of a pump). The outlet portion **187** of the vapor tube **172** is connected by conventional means such as a hose to
20 the headspace above the fuel in the fuel reservoir from where the fuel to be delivered to the vehicle is stored. The central conduit **166B** is connected by conventional means such as a hose to the bottom of the portable reservoir, to be in contact with a liquid fuel.

Using such provisions, when it is deemed desirable to fill gasoline to the vehicle, insertion of the end of the assembly 700 into the open end of the assembly 701 causes the above-described series of events to occur, thus effectively simultaneously, i.e., within about less than 1 second, and permits fueling of a vehicle to occur with no loss of vapor to the atmosphere. Also, since the volume of fuel delivered from the storage tank to the fuel tank on the vehicle is simultaneously compensated for by an equal exchange of headspace volume as between the two fuel storage vessels, no inhibition of flow is observed. Owing also to the nature of the coupling, losses of fuel due to spillage are kept to an absolute minimum, thus reducing fire hazards associated with gasoline spills and effectively eliminating health hazards to persons in the area by virtue of their not breathing volatile materials such as alkyl lead compounds since no spillages occur. These events are depicted in cross-section in **Figures 46 A – 46 F**. Another way of viewing the events associated with the connection sequence may be broken down in the following steps:

1. o-ring, 148, engages with adapter cover, 2. Sealing inner portion of coupler and adapter from outside.
2. o-ring, 130, of 136 engages with face, 48, of internal housing, 18. Sealing inner fluid conduit, 34, from vent cavity, 7.
3. Assy, 136, pushes internal housing, 18, and poppet, 10, back until face, 51, contacts face 40 of body, 4. This opens to vent cavity, 7.
4. Face, 156, of poppet, 158, engages with face, 70, of poppet, 10.
5. Poppet, 156, pushes poppet, 10, open allowing fluid/fuel to flow from 166B to cavity 34.

6. Assy, 136, is pushed back until face, 201, of 102 contacts face, 171, of body, 164.
7. Housing, 18, with face, 48, in contact with o-ring, 130, pushes inner housing, 116, back opening vent cavity, 142?, to vent port, 172.
8. Coupler Assy. continues forward until face, 146, of adapter cover, 144, contacts
5 the heads of screws, 22, of male adapter. Coupler is now fully engaged and all ports are fully open.

The occurrences of the above events are described according to one preferred form of the invention. However, it will occur to one of ordinary skill in the art after reading this specification that the events are controlled by the strengths of the various
10 springs 8, 12, 186, and 140 selected. According to a preferred form of the invention, the event which is the last to occur is the opening of the gap 142 in the assembly 136.

The vent disc 14 on the assembly 700 is spring-loaded, as previously described herein. The purpose of this is to enable ambient air to enter the fuel tank after a quantity of fuel has been removed from the fuel tank by the action of the fuel pump. When the
15 fuel pump removes fuel from the fuel tank during its normal operation, a vacuum will be developed within the fuel tank because of the volume of fuel removed. When the coupling of the present invention is utilized, once the vacuum inside the fuel tank reaches a sufficient level that the spring 12 can no longer hold the vent disc 14 in its seated position, the vent disc is drawn away from its seat, and enables ambient air to enter the
20 tank to compensate for the loss of fuel or other cause of vacuum in the tank, such as a sudden temperature decrease. In addition, the vent disc 14 includes a hole 15 in its surface, which acts as a vent to vent out any pressure which may build up in the tank, owing to increases in temperature or other causes.

FIG. 47 shows a perspective view of a fuel containment system comprising a fuel reservoir **609** having an inlet pipe **611** and containing a liquid fuel and a headspace **613**, and further comprising the coupling **700**, wherein the vapor tube **20** is in effective fluid contact with the headspace **613** above the fuel in said fuel reservoir by means of a tube **615**, and wherein the first end portion **34** of the central bore portion is in effective fluid contact with the inlet pipe **611**.

FIG. 48 shows a perspective view of a fuel containment vessel **617** comprising an outlet **625** and containing a liquid fuel **621** and a headspace **619**, and further comprising the coupling **701**, wherein the vapor tube **172** is in effective fluid contact with the headspace **619** above the fuel **621** in said fuel containment vessel by means of a tubing **623**, and wherein said central conduit portion is in effective fluid contact with said outlet **625**. There is also shown a valve means **627** disposed between said outlet **625** and said central conduit portion.

Consideration must be given to the fact that although this invention has been described and disclosed in relation to certain preferred embodiments, obvious equivalent modifications and alterations thereof will become apparent to one of ordinary skill in this art upon reading and understanding this specification and the claims appended hereto. The present invention further includes all possible combinations of the features recited in any one of the various claims appended hereto with the features recited in any one or more of each of the remaining claims. Accordingly, the presently disclosed invention is intended to cover all such modifications, alterations, and combinations.